LETTERS TO THE EDITOR.

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Penetrating Rays from Radio-active Substances.

THE permanent radio-active substances uranium, thorium and radium all give out two types of rays, one easily absorbed and non-deviable by a magnetic field and the other more penetrating in character and deviated by a magnetic field. In addition to these rays, Villard, using the photographic method, first drew attention to the existence of some very penetrating rays from radium non-deviable by a magnetic field. This result was confirmed by Becquerel.

I have recently examined all these radio-active substances by the electrical method, and have found that thorium, and also the excited radio-activity produced by thorium and radium, emit some rays as penetrating in character as those from radium. Uranium, in comparison with thorium and radium, emits little, if any, of this radiation.

These rays are extraordinarily penetrating in character, and pass readily through great thicknesses of matter. They are certainly as penetrating as the most penetrating rays given out by a hard X-ray tube. The amount of ionisation produced by them is only a very small fraction of that produced by the other two types of radiation. Using testing vessels of ordinary size, the ionisation due to the penetrating rays is of the order of 1 part in 100 of that due to the deviable rays and 1 part in 10,000 of that due to the easily absorbed rays.

In the experiments on radium, 0·7 gram of radium chloride, of activity 1000 times that of uranium, was used. The radiation from this, after its passage through 1 cm. of lead, caused a rapid movement of the needle in the sensitive electrometer employed. The radium was placed in a thick-walled lead vessel and a piece of aluminium waxed tightly over the top to prevent the escape of the emanation. The following numbers illustrate the diminution of the rate of leak in a testing vessel, placed above the radium, with the thickness of the lead traversed by the radiation :—

Thickness of lead.	Current.
·72 cm.	1
·72 + ·62 cm.	·60
„ + 1·24 „	·37
„ + 1·86 „	·25
„ + 2·50 „	·16

The current with ·72 cm. of lead over the radium is taken as unity. It will thus be seen that the current falls off approximately in a geometrical progression with the thickness traversed, and that after passing through 1·86 cm. of lead the intensity is reduced to about one-quarter.

The following table shows the thickness of different metals traversed before the intensity is reduced to one-half :—

Metal.	Thickness in cm.
Mercury	·75
Lead	·9
Tin	1·8
Copper	2·2
Zinc	2·5
Iron	2·5

Assuming this law of absorption to hold, the rays would pass through a thickness of about 7 cm. of lead, 19 cm. of iron and about 150 cm. of water before the intensity would be reduced by absorption to one per cent. of its original value.

The amount of the penetrating radiation from thorium is about the same as for radium, taking into account the ratio of their radio-activities. As the radium employed was about 1000 times as active as thorium, it was necessary to work with a kilogram of thorium nitrate to obtain about the same amount of rays as from the ·7 gr. of radium.

Experiments were also made to see if the excited radio-activity, due to thorium and radium, which gives out deviable and non-deviable rays, also emits these penetrating rays. In order to get measurable effects, it was necessary to obtain intense excited activity. For this purpose a zinc plate was exposed as kathode in a closed vessel containing 300 gr. of thoria. A lead wire was also made very active by exposure as kathode for six hours in a vessel containing a large amount of radium emanation, obtained by bubbling air through a solution of radium chloride. The excited radiation from these two sources was found to include rays about as penetrating in character as those from radium and thorium. The intensity of these rays diminished with the time, rapidly for radium and more slowly for thorium excited radiation. This diminution with time is probably directly connected with the rate of decay of the other known types of radiation from excited bodies.

Since the penetrating rays are present in thorium and radium, and also in the excited radiations due to these bodies, and are absent in uranium, it seems probable that the penetrating rays in both radium and thorium are due to the excited radio-activity, produced in the mass of the compound by the emanations which are unable to escape into the air. According to this view, the production of penetrating rays is a function of that portion of radio-active matter which causes excited radio-activity.

Connection between Absorption and Density.—Some experiments were made to see how the absorption of the rays by matter varied with the density. The coefficient of absorption λ was determined by noting the ratio of the intensities of the rays after passing through a known thickness of matter. The following table illustrates the results :—

Substance.	Penetrating rays.		Deviable rays from uranium.	
	λ	$\frac{\lambda}{\text{density}}$	λ	$\frac{\lambda}{\text{density}}$
Water	·033	·033	—	—
Glass	·086	·035	14·0	5·7
Iron	·28	·036	44	5·6
Zinc	·28	·039	—	—
Copper	·31	·035	60	7·7
Tin	·38	·052	96	13.2
Lead	·77	·068	122	10·8
Mercury	·92	·068	—	—

A comparison table on the right is added for the deviable rays given out by uranium. It will be seen that the quotient of absorption by density is in neither case a constant, but the differences are no greater for the non-deviable penetrating rays than for the deviable rays of uranium. It is interesting to observe that the value of λ divided by the density is for both types of rays twice as great for lead as for glass or iron. It will be seen from the above table that the penetrating rays from radium, compared with the deviable rays of uranium, pass through a thickness of glass about 160 times greater for the same reduction of intensity.

Comparison of penetrating Rays with Röntgen and Kathode Rays.—The question at once arises as to whether these very penetrating rays are projected particles like kathode rays or a type of Röntgen rays. The fact that the penetrating rays are not deviable by a magnetic field seems, at first sight, to show that they cannot be kathode rays. I have repeated the experiments of Villard, and have been unable to obtain any appreciable deviation of the rays, which had passed through ·6 cm. of lead, even in a very strong magnetic field. The photographic method was used, and four days' exposure of the plate was necessary to get an appreciable impression. In some other respects, however, the rays seem more closely allied to kathode than to Röntgen rays. It is well known that Röntgen rays produce much greater ionisation in gases like sulphuretted hydrogen and hydrochloric acid gas than in air, although the differences in density are not large. For example, sulphuretted hydrogen gives six times and hydrochloric acid gas nine times the conductivity of air. On the other hand, with kathode rays the conductivity observed is only slightly greater than for air.

The experiment was made of filling the testing vessel with sulphuretted hydrogen, when it was found that the current for the penetrating rays from radium was only slightly greater than for air. Both this experiment and the results for the variation of absorption of the rays with the density of matter seem to show that the penetrating rays have a closer resemblance to kathode than to Röntgen rays.

It must, however, be remembered that the observations on the relative conductivity of gases and the relative absorption of

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metals for Röntgen rays have only been determined for rays far less penetrating in character than these rays from thorium and radium. Benoist has shown that the relative absorption of Röntgen rays by matter depends to a large extent on the kind of rays employed. "Hard" rays give quite different ratios from "soft" rays. For penetrating Röntgen rays the absorption of the rays by a *given weight* of the elements is a continuous and increasing function of their atomic weights. From the curve of absorption, given in his paper, the variations of absorption with density are much greater for Röntgen rays than for the penetrating rays from radio-active substances.

A very important question arises in discussing the character of these penetrating rays. According to the electromagnetic theory, developed by J. J. Thomson and Heaviside, the apparent mass of an electron increases with the speed, and when the velocity of the electron is equal to the velocity of light its apparent mass is infinite. An electron moving with the velocity of light would be unaffected by a magnetic field.

It does not seem at all improbable that some of the electrons from thorium and radium are travelling with a velocity very nearly equal to that of light, for Kaufmann has recently determined the velocity of the most penetrating deviable rays from radium and found it to be about 95 per cent. of the velocity of light.

The power of these rapidly moving electrons of penetrating through solid matter increases very rapidly with the speed. From general theoretical considerations of the rapid increase of mass with speed, it is to be expected that the penetrating power would increase very rapidly as the speed of light was approached. Now we have already shown that these penetrating rays have very similar properties, as regards absorption and ionisation, to rapidly moving electrons. In addition, they possess the properties of great penetrative power and of non-deviation by a magnetic field, which, according to theory, belong to electrons moving with a velocity very nearly equal to that of light. It is thus possible that these rays are made up of electrons projected with a speed of about 186,000 miles per second.

An interesting speculation arises from the experimental observation that the excited radiations from bodies include these very penetrating rays. Elster and Geitel have recently shown that excited radio-activity can be produced from the atmosphere by exposing a negatively charged wire in the open air. This excited activity is very similar in properties to that produced by thorium and radium. Since the earth is negative with regard to the upper atmosphere, the surface of the earth is itself made radioactive. From the nature of the phenomenon, it necessarily follows that, not only the surface of the earth, but also the whole interior surface of buildings is covered with an invisible deposit of radioactive matter. From the close similarity in the nature of this excited activity from the air with that from radio-active bodies, it is not improbable that the excited radiations from the air include also some of the penetrating rays. If this is the case, our bodies must be continually subject in a small degree to something very like the Röntgen ray treatment, which is now so popular in medical circles. It would also follow that the "spontaneous" ionisation of air, observed in closed vessels by Elster and Geitel and C. T. R. Wilson, may be due, in part at least, to the presence of these rays, which so readily pass through the walls of the containing vessels.

E. RUTHERFORD.

McGill University, Montreal, July 6.

The Future of the Victoria University.

THE interesting contribution on the subject of the Victoria University which Prof. Schuster has made to your columns (July 19, p. 252) invites a few words of reply from one who does not regard the possible disruption of the University with the same complacency.

It may be unknown to many readers of NATURE that the proposals which would disband the University arose in such a way as to preclude that close and careful deliberation on the future of the University and its colleges which would have resulted in a peaceful maintenance of the *status quo* or in a harmonious process of separation. We should otherwise have been saved from the unfortunate situation in which the University is now placed, when one of the colleges and its county is left standing alone for the maintenance of the University.

I refer to this because it might be supposed that the existing state of affairs was the outcome of something like a quarrel. There has been no quarrel; the three colleges of the Victoria University have worked together with a degree of smoothness and good feeling that might seem hardly possible to those who know the strong local sentiment of the two counties and the three towns. There have indeed been many controverted questions in the University history, but the lines of party have, I think, been usually independent of the colleges.

The question of disruption having been raised in such a way that the University itself could not consider it by means of an unpledged tribunal, the Yorkshire College, believing the movement to be detrimental to the interests of education, desired that there should be a Government inquiry by means of a Royal Commission or other body of high authority. This proposal has not been accepted by the majority of the University Court, and as the matter rests now we have the application of Liverpool for a university formally opposed by Yorkshire and formally approved by Owens College, subject to Manchester being also allowed an independent university.

I have no wish to enter here upon the general question of the relative merits of single college and federal universities, but I think there is something to be said on another question of more immediate practical importance, and that is, whether an action so grave as the disestablishment of a university should not be the subject of a strict and impartial public inquiry.

It is true, no doubt, that the Privy Council may be trusted to give a careful and impartial consideration to the question before it, but in the ordinary course of things that would not involve a public inquiry, and the grounds on which any decision was reached would not be made known.

I believe that the future of the Victoria University is a question not affecting that University alone. It raises the much greater issue of the future of university organisation in England, and it seems to me to be of the first importance that the real grounds, if there are any, for the disruption of the federal Victoria University should be clearly set forth in evidence and endorsed by competent authority.

Prof. Schuster says that "the Victoria University is now practically an examining body, which unites all disadvantages." That is just the sort of statement I wish to see sifted by an impartial tribunal. Many of us would say that such a statement cannot be serious; it seems so exaggerated.

It is proposed to dissolve a great educational corporation which after twenty-three years of hard work has acquired real momentum and has come to be recognised as a factor in educational affairs not inconsiderable when compared even with the older universities. I am one of those who believe that a factor of this particular kind has been and is one of the most urgent needs of our time. I believe also that the defects of the Victoria University, which are undoubted, might be largely rectified by a less drastic process than disruption, and that with a revised constitution the University might continue to exist with greater freedom and ease for its constituent colleges and with undiminished effect in their collective action as an enlightened "modern" force on English education.

Surely at least the question is worthy of the most careful consideration and is one that calls for an open inquiry.

In conclusion, I deplore the haste which has been made by advocates of disruption to convince the public of the defects of a University which after all may be obliged to continue its existence.

ARTHUR SMITHELLS.

July 14.

IN writing about the future of the Victoria University in a scientific journal I was anxious to avoid all questions which are immaterial to the main point. Prof. Smithells's letter deals mainly with side issues. The lines of cleavage at our board meetings interest no one but ourselves, and it does not matter now whether Liverpool might or might not have proceeded in a more academic manner.

The position at present is this:—The two senior colleges, representing about three-quarters of the University, believe that independent universities will in future be able to carry out their educational work better than the present federation. Prof. Smithells thinks that we ought to have accepted the proposal of the Yorkshire College to have the whole question referred to a Royal Commission. But surely the only course likely to be followed by men who know their own minds is to ask for what they want; at any rate, it is the only way to get it. It is fortunate, however, that Prof. Smithells's predilection in favour of a federal university may yet be satisfied. Yorkshire is quite large enough to supply the material for a federation, and as an

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